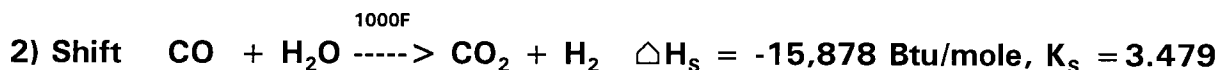
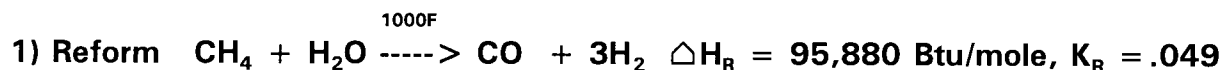


## METHANE/STEAM REFORMING

Methane and steam react chemically at elevated temperatures, and the reaction is accelerated by the presence of a nickel catalyst. The products produced from the chemical reaction are a mixture of carbon oxides, hydrogen, water vapor and unreacted methane. Two reversible chemical reactions are occurring, the exothermic shift reaction, and the endothermic reforming reaction. The second law of thermodynamics sets the free energy and the resulting equilibrium chemical composition of the gas mixture. Catalyst produce essentially equilibrium conditions in a commercial reactor. Three variables set the equilibrium conditions; temperature, pressure, and the steam-to-methane ratio. By way of example, the two parallel reactions, heats of reactions,  $\Delta H$ , and the equilibrium constant, K at 1000°F are:



Chemical reactions at equilibrium compel precise ratios, K, of reactants and products. If the pressure of the methane/steam mix is assumed to be 500 psia and the steam-to-methane ratio, N, is assumed to be 5/1, values of X and Y are calculated as follows:

Let X = number of moles of methane reacting  
and Y = number of moles of CO reacting  
N = steam-to-methane ratio  
P = total pressure in atmospheres

$$\text{Reform: } \frac{(X-Y)(3X+Y)}{(1-X)(N-X-Y)(N+1+2X)^2} = \frac{K_R}{P^2} \quad \text{Shift: } \frac{Y(3X+Y)}{(X-Y)(N-X-Y)} = K_S$$

Solving both equations simultaneously:  $X = .215547$  &  $Y = .205357$

The chemical composition of the equilibrium mixture (both wet and dry basis) and net heat of reaction for this example can be calculated, as follows:

<u>Component</u>	<u>Mole % (wet)</u>	<u>Mole % (dry)</u>
Methane	12.198	42.358
Hydrogen	13.348	46.005
Carbon monoxide	.158	.548
Carbon dioxide	3.193	11.089
Water vapor	71.203	0.000
Total	<u>100.000</u>	<u>100.000</u>

Energy required for chemical reaction:  $X(95,880) + Y(-15,878) = 17,425 \text{ Btu/mole}$

Partial pressure of steam in feed mixture is 5/6(500) or 417 psia: 448°F dew pt.

Energy to heat mixture from dew pt. to 1000°F:  $= 5(4876) + 7333 = 31,713 \text{ Btu/mole}$

Thus, the total heat required in the reforming zone = 49,138 Btu/mole

Chemical energy is seen to be 17,425/49,138, or 35.46% of that required.